PB-217 581

FORD MOTOR COMPANY BY-PRODUCT COKE PLANT, DEARBORN, MICHIGAN, JUNE 20-22, 1951

Environmental Health Center
Cincinnati, Ohio

1951

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National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 217 581

[redacted]

[redacted] MOTOR COMPANY

[redacted] ENGINE PLANT

[redacted], MICHIGAN

June 25-27, 1951
October 30 - November 6, 1962

[redacted]

[redacted]
Public Health Service
Environmental Health Center
Cincinnati, Ohio

NATIONAL TECHNICAL
INFORMATION SERVICE

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GENERAL INFORMATION

1. Organization of Surveys

Representatives of the Ford Motor Company, Michigan Water Resources Commission, and the U. S. Public Health Service, met on May 29, 1951, at the Rouge Plant offices of the Ford Motor Company to discuss extensive improvements, recently completed by the Ford Motor Company, which substantially reduce wastes discharged from the by-product coke plant through the tailrace outlet in the Rouge River. The June, 1951, survey resulted from that conference.

During the preparation of the report on the June 1951 survey, inconsistencies in the results from that survey were noted, in that results for the tailrace outlet failed to check with results from major sources of individual wastes within the plant. Consequently, a special study was initiated on October 30, 1951, for the express purpose of checking phenol and cyanide results which were obtained in the June, 1951, survey. These data are included in Appendix B of this report.

2. Dates of Surveys

The surveys covered the period from June 20 through June 22, 1951, 8 A.M. to 4 P.M. on each day, and the period October 30 through November 8, 1951, 8 A.M. to 4 P.M. each day.

3. Purpose of Survey

The June, 1951, survey was prompted by a request on the part of the Board of Technical Advisers to the International Joint Commission for the purpose of evaluating cyanide reduction as a result of the gas final cooler water recirculating system installed by Ford Motor Company in 1950. Data will be compared with results obtained from previous surveys to determine the effectiveness of improvements.

4. Location of Plant

The Ford Motor Company Rouge Plant is located in Dearborn, Mich. It is bounded roughly by Schaeffer Road, Michigan Avenue, Miller Road, and the Rouge River.

5. Raw Materials

The average daily intake of materials during the June survey period at the coke plant was approximately as follows:

Coal	4282 tons
Lime	4320 lbs.
H_2SO_4 (66° Be)	29 tons

6. Production

The average daily output of coke and by-products during the June survey period was reported as follows:

Coke	3,340 tons
Ammonium sulfate	63,970 lbs.
Gas (cubic feet)	46,750 M
Tar	35,680 gals.
Light Oil	9,950 gals.

7. Plant Operation during Survey

Operations at the coke plant are constant and are carried on 24 hours per day (3 shifts, 8 A.M., 4 P.M., and 12 Midnight), seven days per week.

The plant operates 183 ovens arranged in three blocks of 61 ovens each.

8. Employees

The total number of employees is 507.

9. Water Supply

Detroit River water is used for industrial purposes. A screen-house, containing ten 1/4" screens and wells arranged in parallel, is located on the old Zug Island Channel of the Rouge River. The water flows by gravity through two miles of 15-1/2 ft. diameter tunnel to a pumping station located on the Ford Motor Co. Rouge Plant property. This intake supplies industrial water for the entire Rouge Plant. Total consumption varies from 350 to 600 million gallons per day, depending upon the season of the year.

Detroit city water is used for drinking and for the washrooms. No estimate was given as to the water use for this purpose.

10. Sewers (Industrial Waste)

All wastes from the by-product coke plant, prior to the June, 1951, survey, discharged into the tailrace outlet and to the Rouge River, between Fort Street and Dix Avenue. This tailrace sewer collects wastes from the southeast area of the Ford Motor Co. Rouge Plant.

Other wastes entering the sewer are from the powerhouse, foundry, blast furnaces, locomotive repair shop, and the maintenance shops. The tailrace sewer is 12 feet in diameter. There is an opening to the sewer, just before it enters the Rouge River, where samples can be collected and where current meter measurements of flow can be made. The principal change in the piping prior to the June, 1951, survey was that ammonia still wastes were discharged into the sanitary sewers.

11. Sanitary Sewers

All sanitary wastes discharge to the Dearborn municipal sewers. During the June, and the October-November, 1951, surveys, the ammonia still wastes were also discharged into the sanitary sewers.

DISCUSSION OF PROCESS

The process consists of carbonizing suitable mixtures of pulverized coal under carefully controlled conditions to produce coke for use in the foundry and blast furnaces and also to produce fuel gas for various plant heating operations. Undersized coke, tar, ammonia, naphthalene, and light oils recovered from the gas are processed for disposition as by-products. The general operation of the process is outlined below.

12. Carbonization

The Ford Motor Co. by-product coke plant uses the Koppers-Becker regenerative type coke ovens. The ovens are 42 feet long, 13 feet 3 inches high, and tapering in width from 16 inches to 19 inches to facilitate removal of coke. The individual ovens are separated by walls which contain the vertical heating flues. Characteristics of this type of oven are the individual control and the heating conditions in each flue through separate means of adjustment of the fuel gas, air supply and draft, with the individual regenerators introducing heated air directly at the base of each individual heating flue.

Mixed and crushed coal is delivered to storage bins above each block of ovens. A larry car is filled from the storage bins and moved into position above the oven to be charged. After the oven is charged and the doors are sealed, enriched blast furnace gas and air are preheated by passing through regenerator checkerwork below the flues. The mixture is then introduced into the bottom of the flue in alternate

pairs of walls. Combustion takes place and the hot gases are drawn by the stack draft across the top of the ovens down through the flues in the adjoining walls and through the checkers which recover most of the waste heat. At half-hour intervals the flow is automatically reversed, so that the fuel gas and the air pass through the hot checkers and the waste gas passes through and heats the cold ones. Coke oven gas, which may be used when blast furnace gas is not available, is not preheated, since, because of its higher heat values, a smaller volume is used.

Temperature is controlled by changing the volume of gas input according to the fuel value. The temperature of each flue is checked once each 8-hour shift. Coking time varies from 16 to 32 hours and temperature varies from 2000 to 2400° F. Blast furnace mix is made at high temperature and short coking time, while foundry mix is made at the lower temperature and longer coking time. During the June 1951 survey, coking time was 17 hours 37 minutes at an average temperature of 2198° F. Blast furnace coke was the largest single type produced. Flue temperatures ranged from 2273° F. to 2297° F. during the October-November 1951 study.

13. Quenching and Coke Handling

When carbonization is complete, the incandescent coke is pushed out of the oven with a ram, operated by a mechanical pusher, through a coke guide on the opposite end of the oven and into the quenching car. The quenching car is then run to the quenching station and then to a wharf where quenched coke is dumped. The control for starting the push is located in the quenching car and safety devices are provided

so that the pusher will not operate unless it is on the same oven as the guide and quenching car. Each block has a pusher and a guide but all three blocks are serviced by one quenching car.

The amount of water used per quench must be just sufficient to quench the coke without leaving it wet. About 750,000 gallons per day are used for this purpose. Water runoff is passed through settling basins to reclaim coke breeze washed away during the quench. Quench water is discharged to the tailrace outlet.

14. Gas Collection

Volatile materials and gases released from the coal mix during the heating period are conducted through standpipes into the collector main. A slight pressure is maintained in the ovens and in the collector main by an Askania controller, which opens a butterfly valve when the pressure exceeds 1/2 inch of water. This allows the exhausters to draw more gas to the by-products recovery plant. The standpipes are provided with dampers by which they may be cut off from the collector main, and with lids which may be opened to allow oven gases to bleed into the air. A steam jet siphon on each standpipe exhausts the oven gases into the collector main against the main pressure while the oven is being charged. Other steam jets are provided to aid in cleaning carbon and tar deposits from clogged standpipes.

The inner surfaces of the standpipe downtakes and collector main are sprayed continuously with weak ammonia liquor in order to cool the gas and to keep the mains free of tar, pitch, and ammonium salts. This liquor flows to a tar separator, the tar being drawn off and the super-

natant recirculated to the mains. The excess supernatant liquor in this system goes to the ammonia stills for recovery of ammonia.

15. Primary Coolers

Gas from ovens is drawn by vacuum exhausters through primary coolers in which the temperature of the gas is reduced to 90-96°F. The gas passes upward through primary cooler liquor which washes down over wooden grids. The liquor, containing 10 to 13 grams per liter of ammonia picked up from the gas, removes suspended tar and carries it down into a tank below the grid. This tar is removed continuously through seal-pots while the liquor is circulated through water-cooled coils to maintain the temperature at 90-93°F. at the top of the primary coolers. Tar is run into the flushing liquor line from the ovens.

The flushing liquor, carrying tar washed from gas in the oven standpipes, from the collector main and from the primary cooler seal-pots, flows into a decanter where the tar settles to the bottom. The tar is removed from the decanters and goes to tar storage tanks for ultimate disposal elsewhere.

Liquor overflows into the tank below the primary coolers and is then recirculated to the ovens without further cooling. The temperature is 170-175°F. The surplus liquor formed by condensation of moisture in the coal goes to the ammonia recovery stills.

16. Precipitator and Exhausters

The gas is passed through the precipitator where finely dispersed tar is removed in a high-tension electrically charged field. The tar is removed through a seal and goes into the decanter. From the pre-

cipitator, the gas passes through the exhausters. These are centrifugal compressors which maintain a vacuum of 11 to 11-1/2 inches of water on the gas from the ovens and provide a pressure of 3-1/2 to 4-1/2 inches of mercury on the gas leaving the exhausters. This pressure serves to force the gas through the cleaning processes which follow and finally into the gas holder.

17. Ammonia Recovery

Ammonia from the surplus primary cooler liquor is recovered by steam distillation and added to the gas coming from the exhausters. Quicklime is mixed with enough water to give an easily handled suspension and introduced into the third ring of the still to release fixed ammonia. Wastes from the still are checked several times daily and the amount of lime varied in such a manner that free lime and ammonium salts are held to a minimum.

18. Saturators

Oven gas plus the recovered ammonia is sent to the sulfuric acid saturator to remove ammonia by the formation of ammonium sulfate. The gas is bubbled through anacid solution from a "cracker pipe" below the surface of the acid. Ammonium sulfate crystallizes out and settles into the cone-shaped bottom of the saturator tank. The acid strength is maintained at 60 to 75 grams of H_2SO_4 per liter by the addition of 60° Be. H_2SO_4 as required. The acid concentration is checked every half hour. Twice daily the acid content is increased to 150 to 200 grams H_2SO_4 per liter to break up lumps of salt which may have formed. The acid consumption is checked daily and compared with salt production. Each pound

of acid makes about one pound of dried salt.

The crystallized ammonium sulfate is withdrawn continuously with air ejectors into sludge tubs. The salt settles out while the mother liquor is decanted back into the saturator. The salt is then run into centrifuges for preliminary drain. After further washing and spin-drying in the centrifuge, the salt goes to gas ovens where it is further dried in horizontal rotary tube driers until the moisture content is less than 0.1 per cent. This salt is packed in 10, 50 and 100 pound bags and sold.

19. Acid Separators

The gas passes through acid separators to remove entrained H_2SO_4. The separator is of the baffle type in which the gas stream is caused to change direction sharply many times, depositing the suspended acid on the baffles. Reclaimed acid is returned to the saturator.

20. Final Coolers

The gas from the acid separators flows to the final coolers for removal of the naphthalene. It passes upward through water washing down over wooden grids and is cooled to less than 85°F.

The naphthalene separates out and is carried down by the cooling water into the new gas final cooler water system. The naphthalene collects on the surface of the water and is propelled by water jets to a skimmer. The skimmer collects the naphthalene, sends it to a pump by which it is pumped to storage.

A description of the gas final cooler water recirculating system is given under subsequent heading.

21. Scrubbers

From the final coolers, the gas passes to the scrubbers, where the light oil is removed by counterflow scrubbing with absorption oil. The latter is a high boiling paraffin oil in which the light oil contained in the gas dissolves and can be removed by subsequent steam distillation. Temperature of the gas to the scrubbers is not lower than 60°F. and the absorption oil temperature is kept at around 65°F. From the scrubbers the gas passes to the holder for storage and distribution. The gas going to the holder is mixed with blast furnace gas to maintain a heating value of 490 B.T.U./cubic foot, when corrected to standard conditions. Coke oven gas to the ovens has a heat value of 520-540 B.T.U./cubic foot, depending on coal mix, coking time, and temperature required.

22. Light Oil Stills

The absorption oil containing the light oil picked up from the gas is preheated to a temperature of 248°F. and steam distilled. Exhaust steam is used for this purpose. The vapor is cooled to 203°F. in the dephlegmator to remove the absorption oil carried over, and the light oil vapor is passed over to the condensers. The condensed water and light oil are separated, with the crude oil being sent to storage and the water being discharged to the sewers. The absorption oil removed in the dephlegmator is cooled and recirculated to the scrubbers.

23. Tar Disposal

Tars collected in the decanter are sent to storage for sale to Barrett Division for processing.

24. Control Tests

Control tests are made at regular intervals to insure efficient and economical operation of recovery units. The following conditions should be maintained.

Gas to the precipitator must contain less than 1 grain tar/cubic foot, and gas leaving precipitator less than 0.02 grain tar/cubic foot. Gas leaving the acid separator shall contain less than 2 grams NH_3/1000 cubic feet (ammonia content of raw gas is approximately 200 grams/1000 cubic feet).

Waste from the ammonia recovery still must contain not more than 0.5 gram NH_3/liter, and must contain free lime, but not more than 1 gram CaO/liter.

Dried ammonium sulfate must contain at least 25.25 per cent NH_3 not more than 0.15 per cent sulfuric acid, and not more than 0.25 per cent moisture.

Light oil loss through the final coolers must be less than 0.3 gallon oil/10,000 cubic feet of gas, and light oil content of gas after the scrubbers must not exceed 0.3 gallon/10,000 cubic feet except in summer when it is allowed to go as high as 0.6 gallon/10,000 cubic feet. Debenzolized absorption oil from the light oil must not contain more than 0.1 per cent light oil.

Additional tests may be made when necessary.

POLLUTION CONTROL IMPROVEMENT BY FORD MOTOR COMPANY

Gas Final Cooler Water Recirculating System

25. General Information

A recirculating system was placed in operation in 1950 for the gas final cooler water. This system consists of pumping the gas final cooler water through banks of coils over which cooling water is constantly flowing except in freezing weather. Cooling coils were selected for this installation in lieu of a cooling tower in order to reduce the quantities of hydrogen cyanide and hydrogen sulfide discharged to the atmosphere.

The gas final cooling system drops the temperature of the gas from approximately 50°C. to 25°C. immediately prior to absorption of the light oil. This drop in temperature condenses out some water. This causes a continuous discharge from the gas final cooler to the recirculating system. This was the waste discharge which was measured by means of a knife-edged double end contracted rectangular weir. The average flow was computed to be 16.6 gpm, or 23,900 gpd. This volume may be compared with 5.4 M.G.D. during the October, 1949, survey, and 6.0 M.G.D. during the December, 1947, survey.

26. Operation

The recirculating system has 4 banks of cooling coils in parallel, one long flume, two pumps, and connecting piping. The water enters the bottom of the cooling banks at about 90°F. and circulates upwards through the cooling coils, over which large volumes of mill water are passed. The water leaves the cooling coils at approximately 76°F. From the cooling coils the water is passed through the final coolers and then drops

into the 3 ft. wide flume where it flows into the pump sump. The pump picks up the water and sends it to the cooling coils at a pressure of 65 pounds per square inch.

The gas final cooler water contains naphthalene, tar, and other impurities which coat the cooling coils on the inside. As the cooling coils are in parallel, one bank at a time can be shut down for steam cleaning. The final cooler water is valved off, and a steam fitting is connected to the cooling coils. Steam is then used to clean out the coated pipes. The waste from the steam cleaning operation is discharged into the flume of the recirculating system. The naphthalene is recovered from the flume by propelling the naphthalene by jets of water to the new naphthalene recovery system.

During the steam cleaning operation, several changes were noted in the recirculating system. The pressure on the remaining final cooler water coils increased from 65 psi to 80 psi. This increase in pipe pressure was accompanied by a decrease in pump capacity. The head on the final cooler water overflow weir increased from 1.02" to 1.625", and the 3" pipe overflow at the opposite end of the flume was submerged. Larger quantities of floating wastes were observed on the surface of the flume water, and larger quantities of wastes were spilled over the weir.

After the steam cleaning operation, the clean bank of cooling coils was opened. The head on the pump decreased, which increased the capacity of the pump. The water surface near the pump intake fell approximately 3 feet. The head on the weir overflow fell from 1-5/8" to less than 7/8". Make-up water was added from a 2" mill water supply line located near the

weir. Mill water was added until the head on the weir increased from less than 7/8" to 1-3/8". Then the water surface lowered gradually until the head on the weir was about 1".

27. Leaks

One bank of gas final cooler water coils was tested for leaks. A sample of mill water was taken before passing over the coils, and one sample was taken after passing over the coils. Both samples were tested for phenols. It was found that the water after passing over the coils contained more phenol than the mill water contained before passing over the coils. This indicates that there were small leaks in the bank of coils tested. Since the water was under considerable pressure, small leaks may be expected. This waste water discharged at the tailrace outlet.

SURVEY PROCEDURES

28. Sample Collection

Samples for the June survey were taken at the screen house, ammonia still, gas final cooler water overflow weir, and the tailrace outlet. One grab sample was taken at the gas final cooler water cooling coils to check for leaks in the cooling coils.

Samples from the screen house were collected by Ford Motor Company personnel. The sample was pumped into two 5-gallon glass containers by a Proportioneers chlor-o-feeder continuously over the 8-hour shift. All other samples were collected by U. S. Public Health Service personnel. There were two 5-gallon glass containers at each sample point; one container was clear, and the other container was dosed with copper sulfate for preservation of phenol. Equal portions were taken at half-hour intervals over each 8-hour sampling period and composited. Each sample was divided between the laboratories of the Ford Motor Company and the U. S. Public Health Service for duplicate analyses.

29. Flow Measurements

Screen House - Knowledge of screen house flow was not necessary. Since this intake is the only source of mill water for the plant, comparisons can be made at any sample point with an equal volume of mill water.

Ammonia Still - Flow measurements of ammonia still discharge could not be obtained either by direct measurement or by calculation. Flow from the ammonia still was estimated by coke plant personnel to be approximately 100,000 gallons per day.

Final Coolers - The waste discharge was measured by means of a knife-edged, double end contracted rectangular weir, 6" in length. The weir was centered in a 3 ft. wide flume. The total water depth at the weir was more than 30 inches. The average discharge was 16.6 gpm. For a given set of conditions, the discharge was constant. However, the recirculating system operation was often varied by steam cleaning the cooling coils, switching pumps, cutting in or cutting out one pump, or adding a final cooler or shutting down a final cooler. All of the above conditions occurred during the survey period, and all changed the rate of waste discharge for a short time. During this interval, some of the waste would flow out an overflow pipe into a sewer without being measured. The measurement on the weir was not used to compute the average discharge when waste discharged through the overflow pipe. Periods of zero flow were observed. This zero flow was not averaged with observed weir overflow values.

It is believed that the flow measurements were as accurate as possible under the conditions existing at the time of the survey. In case of any recheck on the quantity of waste overflow, it is recommended that the measurements be taken after 4 P.M. and before 8 A.M., as the above-described steam cleaning process occurs only during the 8 A.M. to 4 P.M. shift. Further, a 90° V-notch weir with liquod level recorder should be installed.

Tailrace Outlet - Previous to the 1947 survey, the Ford Motor Company personnel had done considerable work to determine a representative point for sampling the tailrace outlet. The cross-sectional area at this point was determined by Ford Motor Company personnel to be 104 square feet. This same point was used in the 1951 survey. Flows were measured by means of a cur-

rent meter at a point about 50 feet before the discharge enters the Rouge River.

30. Laboratory Procedures

The following determinations were made on the samples collected:

Phenols
Cyanide
Thiocyanate

The procedure used for the determination of each is given in Appendix A of this report.

DISCUSSION OF RESULTS

Operations at the Ford Motor Company by-product coke plant are reasonably constant during each day. The amount of by-product and the strength of the wastes are affected mainly by the quality of the coal used, the coking time, and temperature. Furnace coke was the main type coke produced during the June, 1951, survey.

In a plant using water which already contains some industrial wastes, the quality of water leaving the plant must be compared to the water entering the plant in order to obtain a fair estimate of the wastes discharged by plant operations. This procedure has been followed in analyzing the data obtained in the present survey. The analytical results obtained on the screen house samples were used to determine the quality of the water entering the plant.

The following table of coal consumption and production of finished products is given for correlation with the analytical results:

Date 1951	Coal Carbonized tons	Gas Produced 1000 cubic feet	Light Oil gallons	Ammonium Sulphate pounds
June 20	4,240	46,575	9,849	61,683
21	4,309	46,800	9,351	65,112
22	4,298	46,875	10,650	65,112
Average	4,282	46,750	9,950	63,970

Average coking temperature 2,198°F.

Average coking time 17 hours 37 minutes

The results of the analyses and the quantities from the various pollution sources are discussed below. These data from both Ford and Public Health Service laboratories are shown in tabular form in Tables 3 and 4.

Appendix B.

31. Waste Discharges

Discharges were measured at the several sampling points and were found to be as follows:

Sampling Point	Flow in M.G.D. (Average)
Ammonia still	0.1 (estimated)
Final cooler	.025
Tailrace outlet	185.97

These flows were used to convert concentrations of phenol, cyanide, and thiocyanate, into pounds per day.

32. Phenol

Concentrations and quantities of phenol were found to be as follows:

Sampling Point	U.S.P.H.S. Laboratory Results June 1951		U.S.P.H.S. Laboratory Results Oct.-Nov. 1951 (1)		Ford Lab'y Results June 1951	
	p.p.m. (Average)	pounds per day (Average)	p.p.m. (Average)	pounds per day (Average)	p.p.m. (Average)	pounds per day (Average)
Screen House	0.199	309	0.301	467	0.149	231
Ammonia Still	566	472	-	-	710	592
Final Cooler	381	79	-	-	329	69
Tailrace	0.161	250	0.146	645	0.262	407
Net Gain thru Plant	Negative	Negative	0.115	178	0.113	176

(1) Flow at tailrace assumed to be the same as during the June 1951 survey.

During the June 1951 survey, concentrations of phenol were determined by both the U.S.P.H.S. Laboratory and the Ford Laboratory. The Ford data indicated that the average daily discharge of phenol from the ammonia still was 592 pounds. The U.S.P.H.S. data for the ammonia still indicated an average daily discharge of 472 pounds. The overflow from the gas final cooler water recirculating systems discharged 79 pounds of phenol daily as determined by the U.S.P.H.S. Laboratory and 69 pounds of phenol daily as determined by the Ford Laboratory. Coke plant operations, therefore produced 551 pounds of phenol daily according to U.S.P.H.S. Laboratory data and 661 pounds of phenol daily according to Ford Laboratory data.

The phenol from the ammonia still did not enter the tailrace sewer as during previous surveys; now, due to a piping change, all ammonia still wastes go to the sanitary sewers which discharge to the Dearborn municipal sewers.

The phenol discharged at the tailrace outlet should be approximately the sum of the phenol found in the screen house plus the phenol found in the final cooler water overflow. This total ranges from 300 as determined by the Ford Laboratory to 388 pounds as determined by the U.S.P.H.S. Laboratory. The Ford Laboratory data showed that 407 pounds of phenol daily were discharged at the tailrace outlet. The U.S.P.H.S. Laboratory results were much lower and were apparently in error at the tailrace.

As a result of the failure of the U.S.P.H.S. tailrace data to check the sum of the components, the special study of October-November 1951 was organized. Samples were collected from the screen house and the tailrace in order to determine the net contribution of pollution from the Ford

Plant. No flow data were determined since operations at the plant were reported to be reasonably constant. The net gain of phenol through the plant checked the Ford data of the June 1951 survey. However, the source of approximately 100 pounds of phenol was not determined.

From the above data, it was concluded that the phenol chargeable to the Ford Motor Company operations and discharged directly into the Rouge River from the tailrace sewer totaled 176 pounds daily. To this value must be added phenol in the still wastes which are presently discharged to the Rouge River through the Dearborn Sewage Treatment Works.

33. Cyanide

The concentrations and quantities of cyanide were found to be as follows:

Sampling Point	U.S.P.H.S. Laboratory Results				Ford Lab'y Results	
	June 1951		Oct.-Nov.1951 (1)		June 1951	
	p.p.m. (Average)	Pounds per day (Average)	p.p.m. (Average)	Pounds per day (Average)	p.p.m. (Average)	Pounds per day (Average)
Screen House	0.08	124	0.00	-0-	0.07	109
Ammonia Still	26.19	22	-	-	24.2	20
Final Cooler	209	44	-	-	248	37 (2)
Tailrace	0.60	931	0.16	248	0.23	357
Net Gain through Plant	0.52	807	0.16	248	0.16	248

(1) Flow assumed to be equal to that of the June 1951 survey

(2) The one Ford Laboratory result was obtained on a day of low overflow from the final cooling water system.

The two laboratory results for samples of the ammonia still and the overflow from the gas final cooler system were reasonably close. The U.S.P.H.S. laboratory data showed 22 pounds of cyanide daily from the ammonia still as against 20 pounds daily determined from Ford laboratory data. The U.S.P.H.S. laboratory data showed 44 pounds daily from the final cooler water overflow.

while the single Ford laboratory results indicated 37 pounds per day.

Coke plant operations as determined from the two points sampled produced 66 pounds of cyanide daily, two-thirds of which came from the final cooler overflow and one-third from the ammonia still. The ammonia still wastes were discharged to the sanitary sewers.

The cyanide discharged at the tailrace should approximate the sum of the cyanide found at the screen house plus the cyanide in the discharge from the final cooler water overflow. Using the Ford laboratory data, the source of approximately 200 pounds of cyanide was not determined. (The ammonia still wastes were discharged through the sanitary sewers). Both Ford and U.S.P.H.S. laboratory tailrace data were thought to be high because the total cyanide found at the tailrace outlet was more than the total cyanide of the known components.

During the resurvey of October-November 1951, samples were collected from the screen house and the tailrace sewer. The cyanide results obtained (1) checked the Ford data determined during the June 1951 survey.

From the above data, it appears that the average daily discharge of cyanide from the tailrace sewer due solely to operations of the Ford Motor Company totaled 248 pounds. In addition, cyanide from the ammonia still is discharged to the Rouge River through the Dearborn Sewage Treatment Works.

(1) Data obtained during the October-November 1951 resurvey are tabulated in Appendix B.

34. Thiocyanate

The concentrations and quantities of thiocyanate were found as follows:

	USPHS Laboratory Results		Ford Laboratory Results	
Sampling Point	P.P.M. Average	Pounds Per Day Average	P.P.M. Average	Pounds Per Day Average
Screen House	0	0	0	0
Ammonia Still	1,579	1,317	1,461	1,219
Final Cooler	733	152	449	94
Tailrace	0	0*	0	0*

* See discussion

The average discharge of thiocyanate from the ammonia still was 1317 pounds and from the final cooler 152 pounds. Coke plant operations, therefore, produced 1469 pounds of thiocyanate, according to U.S.P.H.S. data, of which about 90 per cent came from the ammonia still and the remaining 10 per cent from the final coolers. As the ammonia still wastes were discharged to the sanitary sewers, only 152 pounds of thiocyanate were discharged from the tailrace sewer. This concentration of 0.1 p.p.m. was impossible to detect by the laboratory methods used. Both laboratories recorded zero results from thiocyanate determinations on samples from the tailrace sewer outlet.

SUMMARY

On the basis of the data and supporting information presented in this report, certain pertinent points are presented as follows:

(a) Evaluation of Gas Final Cooler Water Circulating System - The primary purpose of the June, 1951, survey was the evaluation of the gas final cooler water recirculating system as a means of reducing quantities of cyanide discharged into the Rouge River. The evaluation was to be measured by the quantities of cyanide discharged into the tailrace during the June 20-22, 1951, survey, as compared to the quantity discharged during previous surveys. This was accomplished by sampling and measuring the overflow from the cooler system. The system was also evaluated in its effectiveness in the reduction of phenol in the same manner. The results from all surveys are given below in Table 1.

Table 1 - Final Cooler Water Wastes Data

Component	Sept.10-11 1947	Dec.7-12 1947	Oct.23-Nov.3 1949	June 20-22 1951	Per Cent Reduction
Flow, M.G.D.	6.0	6.0	5.4	0.025	
Phenol, pounds	420	255.	172.	79.	
Phenol, pounds per ton coal	.093*	.0565	.0770	.0184	Dec. 1951/1947 = 67.4 1951/1949 = 76.1
Cyanide as HCN, pounds	6050	8230.	1220.	44.	
Cyanide, pound per ton coal	1.34*	1.83	.55	.0103	Sept. 1951/1947 = 99.3 1951/1949 = 96.4
Thiocyanate, pounds	-	-	-	152.	
Coking temperature	-	2253°F.	2016°F.	2198°F.	
Coking Time	-	30 hours	32 hours 32 min.	17 hours 37 min.	
Type coke produced	-	Foundry	Foundry & furnace	Furnace	
Tons coal carbonized	-	4515	2233	4282	

* Based on coal carbonized during December 1947 Study.

A study of the above table indicates the efficiency of the gas final cooler water recirculating system under the conditions as existed during the three survey periods considered. The cyanide load has been reduced more than 96 per cent. The phenol load has been reduced 67 per cent from the 1947 load, and 76 per cent from the 1949 load. All percentage reductions are on the basis of weight of polluting material per ton of coal carbonized. The efficiencies were computed on the basis of waste overflow at the sampling point only.

(b) The average quantities (1) of significant constituents in the wastes discharged daily from the by-product coke plant under the operating conditions prevailing during the survey were as follows:

	Screen House (pounds)	Total in Tailrace Sewer (pounds)	Ammonia Operating Still (pounds)	Chargeable to Plant (pounds)
Phenol	231	407	592	768
Cyanide as HCN	109	357	20	268
Thiocyanate	0	94	1219	1313

(c) Unit values for wastes and constituents from carbonization of one ton of coal were as follows:

Final coolers:	
(1) Overflow waste	5.8 gallons
(2) Cooling water	3090. "
Ammonia still wastes	23.3 "
Phenols	.179 pound
Cyanide as HCN	.063 "
Thiocyanate	.285 "

(1) Ford laboratory data used to compute the values in this table

(d) The average yield of coke and by-products from carbonization of one ton of coal is as follows:

Coke	1,560 pounds
Ammonium sulfate	14.9 "
Gas	10,880 cubic feet
Tar	8.3 gallons
Light oil	2.3 gallons

(e) The average daily discharge of phenol from the tailrace sewer due solely to operations of the Ford Motor Company totaled 176 pounds. The source of 107 pounds of this quantity was not determined.

(f) The average daily discharge of cyanide from the tailrace sewer due solely to operations of the Ford Motor Company totaled 248 pounds. The source of 211 pounds of this quantity was not determined.

COMPARISON OF RESULTS WITH THOSE OF PREVIOUS SURVEYS

During the periods December 7-12, 1947, and October 23 - November 3, 1949, surveys similar to the one heretofore discussed, were carried out at this plant by the Public Health Service. The most important information from all of these surveys is tabulated below for comparative purposes in Table 2.

The most significant result noted above was the reduction of cyanide per ton of coal carbonized. The reduction of cyanide on the basis of data for the December 1947 survey was 96%, and 89% on the basis of the 1949 survey data. A slight increase in phenol per ton of coal carbonized in comparison with the December 1947 survey data was also noted. The June 1951 survey data used in this table was the sum of the pollutants deter-

mined at the tailrace outlet plus the wastes from the ammonia still.

ACKNOWLEDGEMENT

It is desired to express appreciation to the Ford Motor Company for the excellent cooperation and assistance extended during the survey periods.

TABLE 2, COMPARISON OF RESULTS WITH THOSE OF PREVIOUS SURVEYS

ITEM	Dec.7-12,1947	Oct.23-Nov.3,1949	June 20-22,1951
Tons of coal carbonized daily	4515	2233	4282
Coking temperature	2253°F.	2016°F.	2198°F.
Coking time	30 hrs.	32 hrs. 32 min.	17 hrs. 37 min.
Waste Flow per ton Coal Carbonized			
Final Coolers			
(a) Waste	1330 gal.	2420 gal.	3.8 gal.
(b) Cooling Water			3090 "
Ammonia Still	18.5 gal.	31.8 gal.	23.3 gal.
Waste Constituents per ton Coal Carbonized			
Phenol	.14 lb. (1)	.30 lb.	.179 lb.
Cyanide as HCN	1.83 lb.	.55 lb.	.063 lb.
Thiocyanate	-	-	.285 lb.
By-Products Recovered per ton Coal Carbonized			
Coke	1500 lb.	1550 lb.	1560 lb.
Ammonium Sulfate	14.5 lb.	19.7 lb.	14.9 lb.
Gas	10,100 cu.ft.	10,400 cu.ft.	10,880 cu.ft.
Tar	8.2 gal.	7.8 gal.	8.3 gal.
Light Oils	2.5 gal.	2.2 gal.	2.3 gal.
Rate of Discharge at Tailrace Outlet	154.3 MGD	-	185.9 MGD

(1) Figure determined from study of the gas final cooler water system

APPENDIX A

PROCEDURE FOR PHENOLS
ANALYSIS OF COKE PLANT WASTES

A. Special Apparatus

1. Spectrophotometer
2. Distillation apparatus - all glass

B. Reagents

1. Copper sulfate 10%
2. Phosphoric acid 10%
3. Sodium chloride
4. Chloroform
5. Sodium hydroxide 0.1N approx.
6. Phenol
7. Borate buffer
   3.1 gm. boric acid
   3.5 gm. KCl
   32 ml. 1N NaOH
   Make up to one (1) liter. pH 9.4
8. Gibbs reagent

C. Procedure

I. Preliminary screening

1. To 250 ml. of sample, add 2 ml. 10% copper sulfate solution and bring the pH of the mixture below 4.0 by the addition of 10% phosphoric acid solution. Put the mixture in an all glass distillation apparatus. Distill over approximately 200 ml. Heat the distillation, and allow the distilling flask to cool until boiling ceases. Add 50 ml. distilled water to the distilling flask. Resume the distillation and continue until a total of 250 ml. has been distilled over.

2. Acidify the distillate with 1 ml. of 10% phosphoric acid solution, and add 5 ml. of 10% copper sulfate solution. Transfer the mixture to a separatory funnel containing 75 gms. of fine-grained sodium chloride. Make three (3) serial extractions with C.P. chloroform. On the first extraction, shake the mixture until the salt has completely dissolved. Use 50 ml. of chloroform per extraction. Collect the chloroform extract, discarding the aqueous phase

after the third extraction. Combine the chloroform extract. Extract the chloroform twice with 75 ml. portions of 0.1N sodium hydroxide. Discard the extracted chloroform. Combine the alkaline extract and make up to 250 ml. using a volumetric flask.

3. Re-distill as in procedure (1)

II Estimation of Phenol

A. Gibbs procedure

1. To 250 ml. of the distillate obtained from the screening procedure, add 2 ml. 10% copper sulfate solution, and bring the pH of the mixture below 4.0 by the addition of concentrated phosphoric acid. Put the mixture in an all glass still. Distill over approximately 200 ml. Halt the distillation, and allow to cool. Add 50 ml. of distilled water. Resume the distillation and continue until a total of 250 ml. has been collected.

2. Blank - 300 ml. of distilled water.

3. Phenol standard - 500 ml. of a solution, containing 100 ppb phenol, is treated exactly as is a sample under examination.

4. Place all samples, the phenol standard and the blank, in glass stoppered vessels. Adjust the temperature of all portions so that all show less than 1°C difference from the temperature of the phenol control, and the temperature is under 28°C. Add 1[illegible] ml. of borate buffer and mix well by shaking. Add to each portion 5 ml. of freshly prepared diluted Gibbs' reagent (aqueous dilute solution), and shake well immediately.

Allow the samples to stand from six (6) to twenty-four (24) hours under identical temperature conditions, below 28°C. To each portion add 75 ml. of n-butyl alcohol and shake thoroughly. Separate the water and n-butyl alcohol layers, using separatory funnels. Filter the alcoholic dye extract through filter paper. After the paper is drained completely, wash once with n-butyl alcohol, combining the two portions of the filtrate. Make all of the alcoholic extract up to exactly 60 ml.with n-butyl alcohol and mix each portion by gentle swirling. The optical density of all portions, including the control phenol sample, are now determined using a spectrophotometer, the samples being examined at a wavelength of 670 millimicrons, with cells of not less than 5 cm. in light path, and a slit opening of not more than 15 millimicrons. The samples and phenol standard are compared against the control blank as a reference.

B. Bromination Procedure

1. After carrying the sample through the preliminary purification treatment, take an aliquot, estimated to contain about 0.02 gm. of phenol or cresols in terms of phenol, and transfer to a 500 ml. glass stoppered flask. Add just enough distilled water to make the volume 200 ml. Add 25.0 ml. of potassium bromide solution containing 250 gms. in one liter. Add 10 ml. of 1:1 hydrochloric acid solution and place in a water bath held at 25°C. Let stand until the temperature of the solution is 25°C. Add exactly 25.00 ml. of potassium bromate solution containing 3.0 gms. in one liter. Mix well, then let stand at 25°C (preferably within 1° at most within 2°) for exactly 60 minutes, shaking two or three times during this period.

Tentative Procedure for Phenols
Analysis of Coke Plant Wastes

At the end of this time add 25.0 ml. of potassium iodide containing 200 gms. in one liter. Mix well, and let stand at 25°C for exactly 30 minutes, shaking two or three times during this period.

Titrate the liberated iodine with 0.1N sodium thiosulfate, adding starch solution near the end of the titration. Run a blank determination in the same manner.

The difference between the two titrations times 0.0015675 equals the weight of phenol and cresols in terms of phenol.

PROCEDURE FOR CYANIDE ANALYSIS FOR COKE PLANT WASTES

A. Special apparatus

One liter pyrex distillation flask (No. 3360) with Graham condenser or equivalent.

B. Reagents

1. Sodium hydroxide 10%
2. Sodium hydroxide 2%
3. Lead carbonate
4. Tartaric acid 15%
5. Methyl orange indicator (Standard methods)
6. Phenolphthalein indicator (Standard methods)
7. p-dimethylaminobenzolrhodanine indicator 0.02% in acetone
8. Silver nitrate

   a. 0.0192N (3.267 gms. $AgNO_3$/liter)
   1 ml. 0.0192N $AgNO_3$ = 1 mg. CN

   b. 0.001N $AgNO_3$
   1 ml. 0.001N $AgNO_3$ = 0.052 mg. CN

C. Procedure

1. Make a 100 ml. portion of the sample, or one whose CN content is estimated to be approximately 0.5 - 1.0 mg., alkaline to phenolphthalein by adding 10% NaOH drop by drop. The indicator may be added directly to the sample. Avoid gross excesses of the alkali. If the sample contains large amounts of sulfide, it is recommended that the portion of sample selected be kept at a minimum.

2. Add small amounts of dry lead carbonate to the sample and mix well. Repeat this procedure until all of the black lead sulfide is precipitated and a slight excess of white lead carbonate is visible.

3. Filter, using a fast, quantitative, fluted filter paper (Whitman No. 12, 18.5 cm. is recommended). Carefully and thoroughly rinse the flask with distilled water made slightly alkaline, and wash precipitate with the rinsings. Wash again with alkaline distilled water. Discard the precipitate and filter paper; wash the funnel. Transfer the fil-

trate to a distillation flask, rinse the delivery flask.

4. Add 5 - 7 drops of methyl orange to the sample. Acidify with 15% tartaric acid to the methyl orange end point. Add an additional 5 ml. of tartaric acid and dilute to 300 ml.

5. Using the all-glass Graham distillation apparatus, distill 150 ml. of the diluted sample into a receiving flask containing 100 ml. of 2% NaOH solution. The delivery tube from the condenser should extend well below the surface of the liquid in the receiving flask. A 250 ml. volumetric flask can be used as receiving flask.

6. Mix distillate. Test a small portion (25 ml.) of the distillate for sulfide, as in procedure 1. If sulfide is present, remove as in procedure 1 and 2, avoiding excess of the lead carbonate. If no sulfide is present, remove two aliquot portions of the distillate and transfer to titrating vessels. Dilute to 100 ml. and check pH. If the pH is below 11.0, add enough 10% NaOH to bring it up. Add 8 - 15 drops of the p-dimethylaminobenzol-rhodanine indicator and titrate with the standard $AgNO_3$. The color change of the sample is from a yellow to a slight pink (salmon).

7. Run a blank in parallel with the sample and titrate with silver nitrate. Deduct the amount required for the sample. The same amount of indicator should be used for all titrations, the amount of indicator to use depending on the color perception of the operator. An excess of the indicator should be avoided as an intense yellow color may tend to mask the color change at the end point.

D. Calculations

0.0192N $AgNO_3$ = 1 mg. CN

$$\frac{\text{Volume of distillate}}{\text{Volume of aliquot}} \times (\text{ml. of AgNO required} - \text{mls. for blank}) \times \frac{1000}{\text{ml. of sample}} = \text{p.p.m. CN}$$

0.001N $AgNO_3$ = 0.052 mg. CN

$$\frac{\text{Volume of distillate}}{\text{Volume of aliquot}} \times (\text{ml. } 0.001N\ AgNO_3 - \text{ml. for blank}) \times$$

$$0.052 \text{ mg.} \times \frac{1000}{\text{ml. of sample}} = \text{p.p.m. CN}$$

PROCEDURE FOR THIOCYANATE ANALYSIS OF COKE PLANT WASTES

A. Reagents

1. Lead carbonate
2. Sulfuric acid 10%
3. Sodium bisulfite 10%
4. Copper sulfate 2.5%
5. Sodium hydroxide 10%
6. Nitric acid 10%
7. Ferric nitrate 10%
8. Silver nitrate 0.01N
   1 ml. $AgNO_3$ = 0.761 mg. Ammonium thiocyanate

B. Procedure

1. Make a portion of the sample alkaline to phenolphthalein by adding 10% NaOH drop by drop. The indicator may be added directly to the sample. Avoid gross excesses of the alkali.

2. Add small amounts of dry lead carbonate to the sample and mix well. Repeat this procedure until all the black lead sulfide is precipitated and a light excess of white lead carbonate is visible.

3. Filter, using a fast, quantitative, fluted paper, (Whitman No. 12, 18.5 cm. as recommended). Carefully and thoroughly rinse the flash with distilled water made slightly alkaline, and wash precipitate with the rinsings. Wash again with alkaline distilled water. Discard the precipitate and filter paper; wash the funnel.

4. Take a portion (100 ml.) of the filtrate, acidify with sulfuric acid 10%. The acid should be added slowly to avoid violent effervescence. Sodium bisulfite 10% is added, followed by copper sulfate in excess. The latter should be added until the supernatant liquor shows a blue or greenish color of excess of the copper salt, and the solution smells strongly of sulfur dioxide.

5. The mixture is raised just to the boil, and left to stand 3 - 4 hours. The cuprous thiocyanate precipitate, which is frequently dark or black color due to small quantity of CuS, is filtered and thoroughly washed. The washed precipitate is then boiled with an excess of NaOH and again filtered and washed.

Tentative Procedure for Thiocyanate
Analysis of Coke Plant Wastes

6. The filtrate, when cold, is acidified with dilute nitric acid, a few drops of ferric nitrate is added, and titrated with 0.01N silver nitrate until the red color of the ferric thiocyanate just disappears.

7. Run a blank in parallel with the sample and titrate with silver nitrate. Deduct the amount required for the sample.

C. Calculations

(ml. $AgNO_3$ used - ml. $AgNO_3$ for blank) x

$$0.761 \text{ mg.} \times \frac{1000}{\text{ml. sample}} = \text{p.p.m. Ammonium thiocyanate}$$

APPENDIX B

TABLE 3 - RESULTS OF ANALYSES AND CONSTITUENTS IN EFFLUENTS PER 24 HOURS BY U. S. PUBLIC HEALTH SERVICE
FORD MOTOR COMPANY, DEARBORN, MICHIGAN

Source of Sample	Date of Collection (1951)	Method of Collection	Phenols-Gibbs ppm	Phenols-Gibbs lbs.(1)	Phenols-Bromination ppm	Phenols-Bromination lbs.(1)	Cyanides as HCN ppm	Cyanides as HCN lbs.(1)	NH_4SCN Thiocyanate ppm	NH_4SCN Thiocyanate lbs.(1)	Flow MGD measured at 1/2 hr. intervals
Screen House	June 20	8 hour	0.240	374	-	-	0.10	156	0	0	*186.87
"	June 21	Composite	0.196	302	-	-	0.13	200	0	0	*184.61
"	June 22	8 AM-4 PM	0.162	252	-	-	0.00	0	0	0	*186.19
"	Average	Continuous	0.199	309	-	-	0.08	124	0	0	*185.92
Ammonia Still (11)	June 20	8 hour	524.	437	590	492	45.0	38	1597	1332	.10
	June 21	Composite	629.	525	576	480	5.59	5	1590	1326	.10
"	June 22	8 AM-4 PM	545.	455	569	474	28.0	23	1550	1293	.10
"	Average	Every 30 min.	566.	472	578	482	26.19	22	1579	1317	(2) .10
Final Cooler Water	June 20	8 hour	329.	71	356	77	175.	38	588	128	(3) .026
	June 21	Composite	434.	112	420	109	204.	53	691	179	(4) .031
	June 22	8 AM-4 PM	380.	57	400	60	299.	37	921	138	(5) .018
	Average	Every 30 min.	381.	79	392	82	209.	44	733	152	(6) .025
Total of Screen House & FinalCooler	June 20	-	-	445	-	-	-	194	-	128	-
	June 21	-	-	414	-	-	-	253	-	179	-
	June 22	-	-	309	-	-	-	37	-	138	-
	Avg.	-	-	388	-	-	-	168	-	152	-
Tail-Race	June 20	8 hour	0.167	260	-	-	0.36	561	0	0	(7) 186.87
	June 21	Composite	0.156	240	-	-	1.03	1586	0	0	(8) 184.61
	June 22	8 AM-4 PM	0.159	247	-	-	0.40	621	0	0	(9) 186.19
	Average	Every 30 min.	0.161	250	-	-	0.60	931	0	0	(10) 185.92

* Figure for balancing purpose only
(1) Projected to a 24 hour basis
(2) Estimated by coke plant personnel
(3) Average of 3 readings
(4) Average of 8 readings
(5) Average of 11 readings
(6) Average of 22 readings
(7) Average of 17 readings
(8) Average of 14 readings
(9) Average of 8 readings
(10) Average of 39 readings
(11) Ammonia Still Waste to Sanitary Sewers

TABLE 4 - RESULTS OF ANALYSES AND CONSTITUENTS IN EFFLUENTS PER 24 HOURS, BY FORD MOTOR COMPANY

FORD MOTOR COMPANY, DEARBORN, MICHIGAN

Source of Sample	Date of Collection (1951)	Method of Collection	Phenols-Gibbs		Phenols--Bromination		Cyanides as HCN		Cyanides as Thiocyanates		Flow M.G.D. measured at 1/2 hr. intervals
			ppm	lbs.	ppm	lbs.	ppm	lbs.	ppm	lbs.	
Screen	June 20	8 hour	.222	346	-	-	0.12	187	0	0	*186.87
House	June 21	Composite	.145	223	-	-	0.09	138	0	0	*184.61
	June 22	8 AM-4 PM	.080	124	-	-	0.01	16	0	0	*186.19
	Average	Continuous	.149	231			0.07	109	0	0	*185.92
Ammonia	June 20	8 hour	798	666	658	549	44.1	37	1675	1398	0.10
Still (11)	June 21	Composite	782	653	658	549	14.3	12	1217	1016	0.10
	June 22	8 AM-4 PM	550	458	695	580	14.3	12	1490	1243	0.10
	Average	Continuous	710	592	670	559	24.2	20	1461	1219	(2) 0.10
Final	June 20	8 hour	334	72	368	79.9	-	-	213	46	(3)0.026
Cooler	June 21	Composite	342	89	424	109.8	-	-	457	118	(4)0.031
Water	June 22	8 AM-4 PM	312	47	399	59.9	248	37	677	102	(5)0.018
	Average	Continuous	329	69	397	83.0	248	37	449	94	(6)0.025
Total of	June 20	-	-	418	-	-	-	-	-	46	-
Screen House	June 21	-	-	312	-	-	-	-	-	118	-
& Final	June 22	-	-	171	-	-	-	53	-	102	-
Cooler	Average	-	-	300	-	-	-	147	-	94	-
Tailrace	June 20	8 hour	.299	466	-	-	0.31	483	0	0	(7)186.87
	June 21	Composite	.225	347	-	-	0.17	262	0	0	(8)184.61
	June 22	8 AM-4 PM	-	-	-	-	0.20	311	0	0	(9)186.19
	Average	Continuous	.262	407	-	-	0.23	357	0	0	(10)185.92

* Figure for balancing purpose only
(1) Projected to a 24 hour basis
(2) Estimated by coke plant personnel
(3) Average of 3 readings
(4) Average of 8 readings
(5) Average of 11 readings
(6) Average of 22 readings
(7) Average of 17 readings
(8) Average of 14 readings
(9) Average of 8 readings
(10) Average of 39 readings
(11) Ammonia still waste to sanitary sewers

TABLE 5 - RESULTS OF ANALYSIS - U. S. PUBLIC HEALTH SERVICE

CONCENTRATION OF PHENOL AND CYANIDE
IN
SCREEN HOUSE AND TAILRACE OUTLET

		CYANIDE		PHENOL	
Sampling Point	Date	ppm	Net Gain Through Plant ppm	ppm	Net Gain Through Plant ppm
Screen House	Oct. 30	0		.176	
Tailrace Outlet	Oct. 30	.14	.14	.182	.006
Screen House	Oct. 31	0		.176	
Tailrace Outlet	Oct. 31	.13	.13	.188	.012
Screen House	Nov. 1	0		.084	
Tailrace Outlet	Nov. 1	.10	.10	.360	.276
Screen House	Nov. 2	0		.132	
Tailrace Outlet	Nov. 2	.10	.10	.184	.052
Screen House	Nov. 5	Trace		1.143	
Tailrace Outlet	Nov. 5	.33	.33	1.572	.329
Screen House	Nov. 6	-		.220	
Tailrace Outlet	Nov. 6	-	-	.290	.070
Screen House	Nov. 7	-		.183	
Tailrace Outlet	Nov. 7	-	-	.216	.033
Screen House	Nov. 8	-		.294	
Tailrace Outlet	Nov. 8	-	-	.336	.042